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THE MOUNTAINS OF COLORADO.*

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TOPOGRAPHICAL FEATURES.—The mountains of Colorado form, perhaps, the most striking feature in the orology of the United States. Regarding the several ranges which traverse the region between Mexico on the south and the British Possessions on the north as parts of one stupendous whole, whose upheaval in the main may be referred to one geological epoch, we find that along the fortieth parallel the most active telluric forces were exerted, producing the widest expansion and culminating in the loftiest peaks. Between the Sierra Nevada on the west and the Wasatch on the east, the ridges, with their intervening valleys, reach an expansion of not less than a thousand miles. Traced north and south they not only diminish in height but contract in width to about four hundred miles. There are five or six peaks in Western Colorado which attain an altitude of over fourteen thousand feet above the sea, constituting the highest ground in the United States, with the exception of a region on the head waters of Kern River where there is a single point, Mt. Whitney, estimated at fifteen thousand feet.

Between the Missouri River and the Rocky Mountains there is a great swelling of the land, which to the ordinary observer is al-

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most imperceptible. Kansas City, at the junction of the Missouri and Kaw Rivers, is six hundred and forty-eight feet above tide water; First View, near the western line of Kansas, is four thousand, four hundred and seventy-nine feet; and Denver, fourteen miles from the base of the mountains, is five thousand, one hundred and five feet. Thus it will be seen that the traveller along this route is ascending a rapidly-inclined grade which to the eye appears as a dead-level.

From this elevated plateau the mountains rise abruptly, like a great rampart, ridge succeeding ridge, until, on the fortieth parallel, the culminating point is attained at Gray's Peak. This peak was named in honor of the distinguished botanist of that name, by one of his devoted disciples, Dr. Parry, who was the first to measure its altitude, which he found to be fourteen thousand, two hundred and forty-five feet.

There are really two culminating points to the range in this vicinity; one with a rounded outline probably a few feet lower, and the other cone-like in form, which in the distance resembles an aërial pyramid. It would not be inappropriate to attach to the southern point the name of Torrey, who has done so much in determining the botany of the mountain region of the United States; thus linking together the names of two honored observers who throughout a series of years have worked side by side in a common science. Here is the water-shed of the continent. The rains which fall on the western slope find their way to the Pacific through the Colorado River and the Gulf of California, and those which fall on the eastern slope reach the Atlantic through the Platte branch of the Missouri, thence through the Mississippi and the Gulf of Mexico.

Standing at Denver on a clear summer's day, the observer comprehends in the range of his vision, a view rarely surpassed in grandeur and extent. The mountains rise abruptly from the plains like a great wall which can be traced for one hundred and fifty miles. To the south is seen Pike's Peak, distant sixty miles or more, jutting into the plains, and to the north, nearly equidistant, Long's Peak, with its snow-clad flanks and bare scalp, looms up amidst the congeries of peaks. The intermediate distance is filled in with mountains of every variety of contour; some serrated, some crater-like, some pyramidal and some with rounded outlines.

The best time to view this landscape is at early morn. The mountains then resemble a great cloud-bank hanging on the verge of the western horizon. As the sun comes up illuminating the peaks and projecting crags, the landscape resolves itself into definite outlines. Over the whole are thrown broad masses of light and shade, and rock and tree and grassy slope are revealed with wonderful distinctness, while from the snow-fields are flashed back the tints of sapphire and gold. Bathed in that rare and clear atmosphere there is something in this scene ideal, unearthly. "The Delectable Mountains" revealed to the vision of John Bunyan were not comparable in grandeur to these.

While in the distance, the mountains appear to present an impenetrable barrier, yet when approached, they are found to be intersected by numerous cañons which afford practicable routes to their very heart, and enable the explorer, without exhausting effort, to scale their loftiest summits. Their arrangement *en echelon* affords passes which may be surmounted even by railroads.

We have, very properly, incorporated into our vocabulary the Spanish term "cañon" as expressive of a torrent-stream walled in by mountains. Such is the character of all the streams which descend to the plains. Rock-bedded and often rock-walled, they rush and roar in their onward course, and only find repose after their escape to the broad undulating plains.

Ascending a summit from which a bird's eye view of the country can be obtained, the contour of the surface appears like a confused mass of matter thrown up and corrugated when the elements of fire were in the wildest commotion. A tumultuous sea, instantaneously arrested and petrified, would be a miniature representation of what is here seen; and yet, when the geologist comes to carefully examine the structure of the mountains stratigraphically, he finds that they range in nearly conforming lines, whose direction is N. N. W. and S. S. E.

Another striking feature in the topography of this region is the series of high table-lands known as "parks." They are verdant valleys walled in by snowy mountains. The melting snows give rise to numerous springs and rivulets which sustain an almost perennial growth of bunch grass, making these parks according to Fremont "the paradise of all grazing animals," and these streams the favorite abode of the speckled trout. The antelope, the elk, the mountain sheep and the black-tailed deer still abound

in these rich pastures, but the buffalo has been driven away. When, in 1844, Fremont visited the South Park, herds of these animals blackened the surface, and their well-beaten trails afforded the most practicable route through the region; but now they do not even approach the foothills.

The Utes use these parks during the summer as cow lodges, but as winter approaches the herd is driven down to the plain.

Geology. To comprehend the geology of the Rocky Mountains, where the forces of metamorphism have been so powerfully exerted, it is necessary at the same time to study the geology of the Plains, where the strata repose nearly horizontally, and are abundantly charged with fossils. Starting at Kansas City, we first encounter the Coal Measures, which continue to Fort Riley. Here occurs a drab-colored limestone associated with marls, which is regarded as the equivalent of the Permian. Next succeeds a series of bright red and green marls, seen at Salina, which may be Triassic. Above this formation comes the Cretaceous occupying a broad zone nearly coterminous with the plains, conspicuously displayed at Ellis, Fossil Creek, and Fort Wallace. The Miocene-tertiary abuts against the foothills and extends to the east of Denver. At Golden City, the strata of this formation are tilted up vertically, thus showing that within comparatively recent times, this region has been subjected to violent displacements. It is characterized by heavy deposits of coal (lignite) which is successfully mined at Golden City, on Ralston's Creek, South Boulder and other streams descending from the mountains. The beds are from ten to fourteen feet thick—an undue expansion which would indicate that they are pockets, instead of persistent seams. The coal is bright and glossy, but crumbles on exposure to the air, and even when burned in a grate. It contains from twelve to fifteen per cent. of hygrometric moisture which must be expelled in combustion at the expense of the fixed carbon, and therefore prevents it from acquiring that concentrated heat necessary in metallurgic operations. It answers well for household purposes and for locomotives, and in such a region where wood is scarce, its economical value can hardly be over estimated.

As we enter the foothills, layers of brick-red sandstone are observed which, although destitute of fossils, Hayden is disposed to regard as Jurassic. There is also seen a drab-colored limestone,

used at Denver for building purposes, which Hayden regards as Carboniferous. Although ripple-marked, I observed no fossils. Both of these deposits are highly metamorphosed and the strata stand nearly vertical.

Next succeeds a vast series of gneissoidal rocks in which feldspar and mica are the predominant minerals. These rocks everywhere show lines of bedding, but they have been plicated, shattered and tilted up at all angles, and at the same time are cut by numerous divisional planes. The metamorphism of the mass is so complete as to have obliterated all traces of fossils and to have changed the mechanical structure of the rocks themselves. Perhaps there is no region on the continent where the action of igneous causes is displayed on so grand a scale as here.

The true granites are only seen along the axes of elevation. They play an important part in the structure of the region, constituting, as it were, its framework.

In the Rocky Mountain system is probably represented the whole assemblage of formations from the Azoic up to and including the Jurassic, but so thorough has been the processes of metamorphism, at least on the Atlantic slope, that it is impossible to recognize subordinate groups. On the western slope, Fremont long ago recognized rocks with organic remains, which he referred to the Oölite, which is a member of the Jurassic. The investigations of Whitney in California have settled this question — that it was at the close of the Jurassic epoch that this vast assemblage of formations was metamorphosed and folded into great ridges with their intervening valleys. The eruptive rocks accompanying this upheaval were for the most part granites, probably in a pasty condition, as in this association there are no traces of volcanic products.

Vein Phenomena.— It was at this time that the granites and metamorphic rocks became impregnated with the precious metals, such as gold and silver, which are found concentrated in veins and fissures. At a subsequent date — during the earlier Tertiary Period—a series of volcanic vents were formed along the line of previous disturbance, from which were poured forth a series of igneous products, such as basalts, lavas, etc. These also became impregnated with the precious metals, of which the famous Comstock lode in Nevada, as shown by Richthofen, is a notable example. Thus,

then, the formation of the mineral veins of this region may be referred to two distinct epochs.

The veins of Colorado, thus far mined, belong to the older class. The gold-bearing veins, unlike those of California, contain in their gangues, copper and iron pyrites, blende and galena, and so intimately is the gold connected with these sulphurets, that great loss is incurred in its extraction.

The veins of silver have, also, their associations of base sulphurets, and the silver itself appears under the forms of sulphuret and antimonial. Black Hawk and Central City are the main sites of gold mining, while Georgetown is the focus of silver mining. The annual product in the precious metals as estimated by Clarence King is about three million, two hundred and fifty thousand dollars. As constituting a part of the volcanic phenomena, may be mentioned the frequent occurrence of hot springs throughout the whole area occupied by this mountain system. In Colorado, the most noted are those of Middle Park and Idaho. The former are not readily accessible, and I am not aware that their waters have been subjected to analysis. The latter are now resorted to for their remedial virtues in cases of rheumatism, paralysis, and cutaneous affections. These springs issue from the left bank of Soda Creek, and are three in number. The flow is not copious, being about ten gallons a minute. The temperature is 109° F. An analysis of the water by Mr. J. G. Pohle of New York, gave one hundred and seven grains of solid matter to the gallon, made up of the following ingredients:

Carbonate of Soda,	30.80
Carbonate of Lime,	9.52
Carbonate of Magnesia,	2.88
Carbonate of Iron,	4.12
Sulphate of Soda,	29.36
Sulphate of Magnesia,	18.72
Sulphate of Lime,	3.44
Chloride of Sodium,	4.16
Chloride of Calcium and Magnesium, of each a trace,	
Silicate of Soda,	4.08
	107.08

Climate.—One of the most striking peculiarities of these mountains is the absence of a perpetual line of congelation. Mr. Bowles in his little work on this region, calls special attention to this significant fact, and points out the diversities between these mountains and those of Switzerland; and what I propose to state under

this head will be but an amplification of this train of thought. It is true that in midsummer even large snow-fields are to be seen, but it is the result of the winter's accumulation in the ravines and other places sheltered from the sun. Above the snow-patches the grasses thrive and the delicate lichens in thin flat crusts adhere to the rocks which form the dominating peaks. The tree-line ascends to eleven thousand feet. Potatoes, beets and cabbages and the hardier cerealia, such as oats and barley, are successfully cultivated at nine thousand feet; at ten thousand feet flowers bloom, often sending forth their petals close by a snow-bank. Thus January and May are commingled. Thriving under such conditions is a wild columbine which clusters in large patches and bears a deep purple blossom fringed with white. This profusion of gaudy flowers arrested the attention even of the untutored savage, and the Utes gave to the plant the name of *idaho* or purple flower. The white explorers applied this name to a town, which they founded on the banks of Clear Creek in Colorado, and a band of miners swarming thence to a region farther north, carried with them this name, which subsequently became attached to a territory of the United States.

During the summer, day after day, the sun comes up without a cloud; but midday passed, there is an afternoon mist, often accompanied by thunder and lightning. At Denver the phenomena of gusts of wind and thunder and lightning are of almost daily occurrence, and yet without a drop of rain. During the month of July last, the precipitation was fifty-one one-hundreths of an inch. In the mountains there are "cloud bursts," when the rains fall in a cataract and filling the gulches sweep every thing before them.

The electrical phenomena often occurring during a storm on the summits of the mountains are most vivid, and dangerous to those caught in such exposed positions. There are authentic instances where the body becomes so surcharged with electricity that the hair stands out rigidly, and sparks are emitted from the person thus isolated when approached, and every metallic article becomes luminous.

Statistics as to the amount of rainfall in the mountains have not been collected, but at Denver it only reaches about thirteen inches during the year.

In that dry and bracing atmosphere the thermometer may rise to ninety degrees F. and yet without producing those depressing

effects experienced in a more humid climate. Perspiration is almost insensible. The residents represent that autumn is the pleasantest portion of the year, and that this delicious season continues until January, when the winter seriously sets in and continues until May. The snows are not deep, and on the cliffs exposed to the direct rays of the sun rarely remain over a few days. Such is the climate in the cañons, but on the higher peaks a mantle of white begins to form late in September and continues to accumulate until spring.

The temperature at Denver, two thousand, one hundred and five feet above the sea, does not differ essentially from that at Cambridge, Massachusetts, seventy-one feet above the sea, while the difference of latitude is about two degrees. This is shown in the subjoined table:

	Spr.	Sum.	Aut.	Win.	Mean.
DENVER.	45.6	69.0	39.9	30.3	46.2
CAMBRIDGE.	44.3	68.6	50.1	26.2	47.3
	1.3+	.4—	10.2—	4.1+	1.1—

Mt. Washington, in New Hampshire, is six thousand six hundred feet above the sea, and the little band of observers who last year passed the winter upon its summit, encountered all the rigors of an arctic climate. At Idaho Springs, in the heart of the Colorado Mountains, and one thousand one hundred and forty-two feet higher, cattle may pass the winter without shelter. A warm breath permeates the valleys, mitigating the severity of winter, and rendering the climate agreeable to the human system. I will not pause to discuss the causes of this anomaly, so at variance with what is observed in other regions lying within the temperate zone.

If we turn to the Alps, from which we naturally derive our ideas of the effects of temperature by reason of elevation, we shall find that far different conditions prevail. At the height of eight thousand feet the line of perpetual snow is encountered, and not less than four hundred glaciers exist, extending over an area of fourteen hundred square miles. Mt. Blanc, fifteen thousand, seven hundred and forty-four feet above the sea, about fifteen hundred feet higher than several of the Colorado Peaks, is scaled only by cut-

ting steps for a long distance in an icy acclivity, and its scalp is always snow-clad. The pines and larches disappear at five thousand, nine hundred feet, while the mosses and lichens continue up to the line of perpetual snow. The cerealia are not grown higher than three thousand, eight hundred, or four thousand feet, but in one sheltered place, Skala, barley ripens at five thousand, nine hundred and fifty feet above the sea.

In order to produce glaciers there must be a marked relief and depression of the surface and a marked vicissitude between the summer and winter temperature. While the Andes in the tropics rise into the region of perpetual congelation, there is not that variation of temperature which is necessary to produce *nevè*, that aggregation of large crystalline facets, so different from river-ice, which make up glaciers. Many parts of Siberia and North America are within the line of permanent ground frost, and yet no glaciers are formed. In the Alps, according to Forbes, the summer's thaw percolates the snow to a great depth with water. The frost of the succeeding winter penetrates it far enough to freeze it to at least the thickness of one year's fall; or by being repeated in two or more years, consolidates it more effectually. The glacier commences near the line of perpetual snow, and renewed by the accumulation of each winter descends to a lower level, its extremity being constantly dissolved by the summer's heat.

In the Colorado region the conditions of relief and depression of surface are sufficient to maintain glaciers, but the temperature is not sufficiently low to maintain a line of perpetual congelation on which they depend for their existence.

Glacial Action.—Two enquiries naturally suggest themselves; were these mountains formerly encased in ice? Were these plains subjected to that erosive action so conspicuously displayed in New England and the region of the Great Lakes?

The western limit of the Erratic block group, as observed by me, is in the immediate valley of the Missouri, between Leavenworth and Lawrence. The western limit of the striated rocks, as observed by Hayden, is at Plattsmouth, also in the immediate valley of the Missouri.

In crossing the plains, which expand to more than six hundred miles in width, there is an absence of all drift phenomena, such as boulders, gravel knolls, and planed surfaces, until Denver

is approached. Here the soil reposes on a water-washed gravel, but the beds of the streams are composed of shifting sands. Advancing towards the foothills, small boulders are observed strown over the surface, and occasionally it is traversed by ridges of sand.

In fact the observer experiences a feeling of disappointment at the absence of the more striking drift phenomena; for naturally comparing this region with the Alps, he expects to see great outlying masses of rock which have been transported far from the parent bed; accumulations of gravel and sand in the nature of terminal moraines; and rock surfaces which have been planed down and striated. Entering the mountains, the cliffs are jagged, no where exhibiting those smooth outlines seen in the Alps and called by De Saussure, *roches moutonnées*. The enclosing banks of the streams are made up of large egg-shaped pebbles and occasional boulders two and three feet in diameter. None of these materials, so far as I have observed, are *striated*, while the true drift pebbles are almost invariably marked by such signs. Taking Clear Creek as the line of my observation, these water-worn materials do not attain an elevation above its bed of more than one hundred feet, and tracing the smaller streams to higher elevations they soon disappear and are replaced by angular fragments.

The transporting power of the present streams is very great. They have a descent of from fifty to one hundred feet to the mile, and, swollen by the spring freshets, the waters sweep down with sufficient force to bear along the largest boulders here observed, particularly if entangled in ice.

Another phenomenon characteristic of all true drift regions, is entirely wanting on the plains, and but sparingly represented in the mountains; and that is the absence of lakes. Professor Ramsey, as far back as 1862, in a paper communicated to the Geological Society of London, pointed out the fact that lakes were very numerous in those regions where the evidences of ice action were most manifest, and comparatively rare in tropical and subtropical regions; and maintained that they were actually due to the erosion of their basins by glaciers.

The scenery of the Alps derives one of its principal charms from the abundance of its lakes. We may refer to Geneva, Constance and Zurich, near the borders of the mountains, to the Lakes of the Four Cantons, Lago Maggiore, and Como, and the

series of Austrian lakes, to say nothing of the innumerable pools of water which occur near the summits of the loftier ridges.

The scenery of Sweden and Norway is diversified by these inland enclosures of water, which become rare in the more temperate climates.

If we consult a map of the northern portion of our own country, we shall find that, leaving out the great chain of the Canadian Lakes, and such collections of water as Winnepeg, Athabasca, Slave Lake and Bear Lake, all the way from Minnesota to the Arctic Sea, there are innumerable smaller lakes which enable the voyageur in his canoe to penetrate to every portion of the country. In southern Wisconsin the lakes are few and in Illinois they disappear almost altogether.

On the plains there is not a permanent collection of water to which we attach the name of lake; and in the mountains they are rare. This is the more surprising when we consider how actively the forces of elevation and subsidence have been exerted. The Great Basin, it is true, is characterized by numerous lakes, most of which are of a highly saline or brackish character, but in a region where the streams are cut off from the sea, it is but natural that the waters should accumulate in the depressions.

There may have been a time when the annual precipitation of rain was greater, and consequently the transporting power of the streams was increased beyond their present capacity, but there are few phenomena with regard to the distribution of the superficial materials which cannot be explained by a resort to causes now in operation. Professor Whitney has arrived at substantially the same results with regard to the Pacific slope.

In concluding these observations, I may remark that the railroad facilities are now so far developed that to an inhabitant of the Mississippi Valley, this region is as accessible as the White Mountains of New England. The ordinary observer is brought in contact with some of the grandest scenes in nature, whilst to the geologist and botanist are opened new spheres of observation — a constantly recurring succession of the most interesting and varied phenomena.